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Temporal succession following flash flooding in Damietta Branch

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ABSTRACT

Extreme weather is probably a consequence of climate change, especially periods of wet and dry spells. Extreme weather naturally impact riverine ecosystem. Therefore, comprehensive investigations of ecological processes during and after extreme events of October 2016 were carried out at Delta Barrage, Damietta Branch of the River Nile. Ten surface water samples were collected and analysed for eight physio-chemical parameters, namely temperature, pH, turbidity, dissolved oxygen, electrical conductivity, nitrate, oxidation reduction potential and crude oil. In addition, planktonic parameters were investigated. The present result showed that water quality during the flooding periods statistically changed when it was compared with pre-flood period. Moreover, the populations of both phytoplankton and zooplankton were significantly decreased in response of flash flooding. However, after five days of post flooding, a recovery has been statistically detected for some organisms.

INTRODUCTION

News about extreme precipitation events and consequent enormous floods are common. Those extreme events may cause serious damaging effects on the environment and the human society through significant losing of life and enormous economic damage with most caused by flash floods (Meehl, *et al*., 2000; Seneviratne, *et al*., 2012; Lumassegger, *et al*., 2017). According to recent climate model which predict the near future, it is very likely that high floods will occur more frequently in certain areas "such as Mediterranean region, southern and central Europe, southern Africa, northeast Brazil, central North America, central America and Mexico" (IPCC, 2001; Prudhomme, *et al*.; 2002, Senior, *et al*., 2002; RICCAR, 2015). However, the quantitative prediction of heavy rain periods remains a major challenge for forecasters and research meteorologists (Rusjan, *et al*., 2009; Ledger and Milner, 2015).

The study of extreme flooding events and their impacts on terrestrial and aquatic ecosystems and their magnitude and duration has become an important issue (Easterling, *et al*. 2000). Often a single extreme flood event has a stronger impact on an ecosystem than a gradual flood trend (Parmesan, *et al*., 2000). The extreme periodic flooding has been shown to stimulate increased aquatic production in macroinvertebrates and result in strong reproductive year classes for fish species that use floodplain habitat for forage or spawning (Maher, 1994). Also, it provides strong natural disturbances capable of essentially resetting aquatic and floodplain communities dominated by flood tolerant or mobile species (Poff and Ward, 1989; Friedman *et al*., 1996) and early succession stages of vegetation (Yanosky, 1982; Waring and Stevens, 1987). On the other hand, single flash floods, especially in the desert streams are defined by their sudden arrivals, short durations, and extensive physical and biological impacts. These extremes are a consequence of the powerful convective thunder storms that often generate flash floods in the desert regions (Fisher *et al*., 1982).

In Egypt, several flooding and extreme surface runoff events associated with large amounts of transported sediments occurred in the last years, where they frequently take place in many arid mountainous regions namely Upper Egypt, Eastern Desert and Sinai Peninsula (Khider, 1997; Ashour, 2002; Moawad, 2013, Moawad *et al*., 2016; Yusuke *et al*., 2017). Such flash flood can be generated instantly during or shortly after a rainfall event, especially when high intensity rain falls on steep hill slopes with exposed rocks and lack of vegetation. As a consequence, the debris load is mostly high, which further magnifies the destructive power of a flash flood (Cools *et al*., 2012 and Moawad *et al*., 2016).

Relatively little is known about the biotic and abiotic effects of the flash floods in the montane desert streams and its effects on the Nile River because the timing of individual flash floods is unpredictable. This makes before and after data hard to obtain without careful planning. The purpose of this study was to characterize a reach of Nile River to the flash flood and document the immediate biotic and biotic changes caused by the flash flood. Therefore, the main goal for this study was to focuses on the impacts of exceptional events on the Nile River "Damietta Branch". This was achieved with the following objectives:

1- Measuring the surface water quality in many locations pre and post the flooding period.
2- Measuring changes in the planktonic community structures and show how the flood alters their structures.
3- Providing a foundation for understanding how the flash floods shape the ecosystem structure and function of the Nile River within a short time period.

MATERIALS AND METHODS

Study area

Damietta Branch is mainly used for irrigation purposes. It is equally fertile delta for a further 245 km. The flow of Damietta Branch is controlled at its head by the Delta Barrage Damietta Branch, which was constructed in 1937 which replaces the hydraulic functions of the Mohammed Ali Barrage Damietta Branch, located 270 m upstream which was commissioned in 1862. This location is distinguished by a pronouncing water level difference between the upstream and downstream of the Delta Barrage–Damietta Branch. This head is 3.8 m. However, the location is characterized by a sufficient water discharge of 330 m^3/s "28.5 million m^3/day" (ECRI, 2014).

Sample collection

Torrential rain and flooding began in Egypt late on 26 October, 2016 in several towns in Upper Egypt and along the Red Sea coast. On 1st November 2016, the color of the main stream of the Nile River changed to brown as a result of the flash flood, especially near Greater Cairo.

To study the effect of flash flood on the physico-chemical and biological water quality in Damietta Branch, El-Qalyoubia Governorate, 10 locations were selected to collect the water samples as shown in Figure (1). These locations were selected at lat 30° 02' 25" N and longitude 31°14' 37" E, at a distance of 550 m from the National Water Research Center (NWRC) as shown in Figure (1). Water samples were collected daily at 9 am from the selected study area which started at 2nd November 2016.

Fig. 1: Site location and water samples

Water quality samples

Ten locations were selected in Damietta Branch. At each location, measurement of several surface water variables was achieved at least daily before and during the flood period using a handheld (Manta 2) multi-parameter meter; means Manta 2, Sub2, and Sub3 are trademarks belonging to Eureka Water Probes. Those variables included dissolved oxygen (DO), temperature (ºC), electrical conductivity (EC), turbidity, nitrate (NO_3), oxidation reduction potential (ORP) and crude oil (CO).

Phytoplankton samples

At each location, collection of phytoplankton samples was achieved at least daily before and during the flood period. In each location, water sample of one liter was collected and preserved immediately in Lugol' iodine solution in a ratio of 1:100. The sample was transferred into a glass cylinder and left 5 days for settling. About 90% of the supernatant was siphoned off; using plastic tubes covered with plankton net (5 microns) and adjusted to affixed volume. The sample was examined using inverted microscope. The drop method was applied for counting and identification of different algal speciesas in APHA (1985). Phytoplankton biomass was calculated from recorded abundance and specific biovolume estimates, based on simple geometric solids (Rott, 1981) and assuming unit specific gravity. For phytoplankton identification, the following references were used Abdin (1948b), Bachmann (1936), Pennak (1953), Soileau *et. al.*, (1995), Wallace & Snell (1991) and Touliabah (1996). as in APHA (1985). Phytoplankton biomass was calculated from recorded abundance and specific biovolume estimates, based on simple geometric solids (Rott, 1981) and assuming unit specific gravity. For phytoplankton identification, the following references were used Abdin (1948b), Bachmann (1936), Pennak (1953), Soileau *et. al.*, (1995), Wallace & Snell (1991), Touliabah (1996) and Mohammed (2015).

Zooplankton samples

Ten locations were selected in Damietta Branch to collect the zooplankton. At each location, collection of zooplankton samples was achieved at least daily during the pre and post flooding period. Each sample was collected by filtration of 100 liters of water through plankton net with 55 microns mesh diameter. The sample was preserved immediately after collection in 4% formalin then the sample was made up to a standard volume (100 ml).Triplicate of one ml sub sample of each sample were counted and identified by the aid of a binocular microscope The samples were identified up to species level as possible according to Penn (1943, 1954), Pennak (1953), Bardach *et. al*, (1972), Soileau (1975) and Mohammed Khadra (2015).. The average count of months was taken and the results were expressed as the number of organisms per cubic meter at each site.

Statistical analysis

To study the effect of flood on the surface water and the planktonic community structures in Damietta Branch, statistical analysis was applied to analyze the difference among duration (before and during the flood period) using repeated samples taken over time. Paired sample T test (SPSS 17) was used to test differences among pre and after flooding period (two tailed, p=0.05).

RESULTS AND DISCUSSION

In this research, the present study focused on an extraordinary event in the Nile River. Here it hypothesized that such a flash flood period can cause exceptional conditions in a Nile River as compared with those in the previous condition. To test this hypothesis, the present study analyzed physical, chemical and biological conditions in pre and post flooding periods. Patten, *et al*. (2001) carried out a comprehensive study on the effects of a seven-day experimental controlled flood on the chemistry and biology of the Colorado River, U.S. However, the effects did not seem to be long-lasting. Shannon, *et al*. (2001) and Valdez, *et al*. (2001) reported that macro-invertebrates, filamentous algae and fish recovered within three months after the flood.

Concerning the surface water characteristics of post the flooding event, the present result showed that there was a strong relationship between before and during the flood period in Damietta Branch for the dissolved oxygen (DO), temperature (^{o}C), electrical conductivity (EC), turbidity, nitrate, oxidation reduction potential (ORP) and crude oil (CO) as shown in Table (1).

Analysis of the water temperature gradient indicated that the water temperature was significantly similar during pre and 1, 2, and 3 days post of the flooding; however, it became cooler after 4 and 5 days from the flooding.

Concerning the pH, Boyd (1979) stated that pH is a measure of hydrogen ion concentration in water. It may be either in basic form or acidic form. Its value fluctuates in the day when phytoplankton utilizes carbon dioxide for photosynthesis and rises but it drops when respiration take place in the night. The best pH is when it's ranging from 6.5 to 8 but when it is below 4 and above 9, it is regarded as lethal. In the present result, regarding the water quality data, indicated that under pre flooding conditions the surface water was slightly to moderately alkaline with a pH of 8.1. But, post of the flooding period, the values of pH was increased to 8.58 and 8.73 as shown in Table (1).

Concerning the dissolved oxygen, it plays a role in the process of oxidation and reduction of organic and inorganic materials as well as it is necessary element to all forms of life. In the present study, the field analyses showed that the surface water in the Damietta Branch contained adequate dissolved oxygen. Comparing dissolved oxygen values during pre and post flooding, the statistical analysis showed significant differences between them (p>0.05) except for 4 days post the flooding period as shown in Table (1). During the flooding period, the dissolved oxygen increased in the surface water more than the pre flooding period which indicates that the level of water quality has been improved. Similarly, Egborge (1971) indicated that dissolved oxygen levels are generally lower in river channels during the dry season than during the flood season.

Concerning oxidation reduction potential (ORP), that measures the ability of a lake or river to clean itself or break down waste products, such as contaminants and dead plants and animals; it can be used as indicator to explain the water condition. When the ORP value is high, it indicated that there is lots of oxygen present in the water. This means that bacteria that decompose dead tissue and contaminants can work more efficiently. In general, the higher the ORP value, the healthier the lake or river is (Wetzel, 1983). In healthy waters, ORP should read high between 300 and 500 millivolts. In case of the present result, the field analysis showed that, the flooding led to aerobic conditions as a result the value of ORP increased from 215.98 millivolts during the pre flooding period to about 284.64 millivolts after the flooding period but did not show any significant difference as shown in Table (1). This trend is similar to the trend of DO which indicates that ORP depends on the amount of dissolved oxygen in the surface water.

Concerning the turbidity, it has a complex effect on the properties of water bodies such as the effects on the high penetration of light and the uptake of solar radiation. On the other hand, Boyd (1979) indicated that turbidity of water result from planktonic organisms is a desirable trait, but the turbidity that is caused by suspended clay and silk particle is undesirable because it prevents the penetration of light into the water and consequently reduces the plalanktonic growth and its population. In case of the present result, the floodwaters became highly turbid with increased suspended sediment after one day post the flooding and then dropped to a minimum values to reach 5.43 after 4 days of flooding (Table 1). Similar, studies were conducted by CMRI (2002) and Abdel Meguid, *et al*. (2002) indicated that the main channel of both Lake Nasser and Khor Kalabsha were highly turbid during the flooding season. Also a marked increase in turbidity levels was observed in South Africa following increased river flow with high concentrations of suspended silt and sediment (Gama, *et al*., 2005).

Concerning the electrical conductivity (EC) of the Nile River at Damietta Branch, the present result showed that it ranged between 149.1 and 557.8 as shown in Table (1). EC generally declined after the first spillover associated with flooding, especially on the first day post flooding. It is clear that the fresh water (rain) lowers the conductivity level because rainwater has low conductivity and the increase in water levels dilutes mineral concentrations. Similarly, Jones (2013) mentioned that increased delivery of water to freshwater ecosystems during flood events results in a decrease in water conductivity.

Concerning the crude oil (CO), it is considered as a naturally liquid with a complex mixture of organic molecules, mostly hydrocarbon with varied chemical and physical properties. The present result showed that the flash flooding in 2016, led to unusually high loading of CO, being statistically significant as high as ever measured pre flooding period as shown in Table (1).

In addition, the present result showed that the flash flooding altered the total amount of nitrate processed (Table 1). Nitrate concentrations after one day post flooding period was higher than the initial values of “pre flooding period”. This may attribute to dead of some organisms such as phytoplankton, rotting plants.

After that, the values of nitrate decreased to reach to the minimum value of 3.24 mg/l after four days of flooding and finally increased sharply after five days post the flooding as shown in Table (1). This fluctuation may attribute to utilization by phytoplanktons or the sediments which release nitrate into the waters that flow through or over them.

Concerning the phytoplankton and its density, the present result showed that there were (5) major groups of phytoplankton found in the Damietta Branch as shown in Figure (2) and Table (2). These major groups were the Chlorophyceae (green algae), Baccillariophyceae (Diatom algae), Cyanophyceae (Blue - Green algae), Dinophyceae and Euglenophyceae. Chlorophyceae was the most diversified group (17 taxa), followed by Bacillariophyceae (13 taxa), Cyanophyceae (10 taxa), Dinophyceae (2 taxa) and Euglenophyceae (2 taxa). The statistical analyses showed that the phytoplankton was generally more numerous during the pre flooding period. However, it was subjected to drastic changes as consequences of an unusually rainy flash period via the desert into the Nile River. Similarly, Imeybore (1970) found that phytoplankton biomass was considerably lower during the white flood than during the black flood in Niger River. In this context, the turbulence caused by water turbidity could be regarded as a factor influencing water color and light conditions that consequently affect the phytoplankton assemblages in Lake Nasser (El-Otify, 2002).

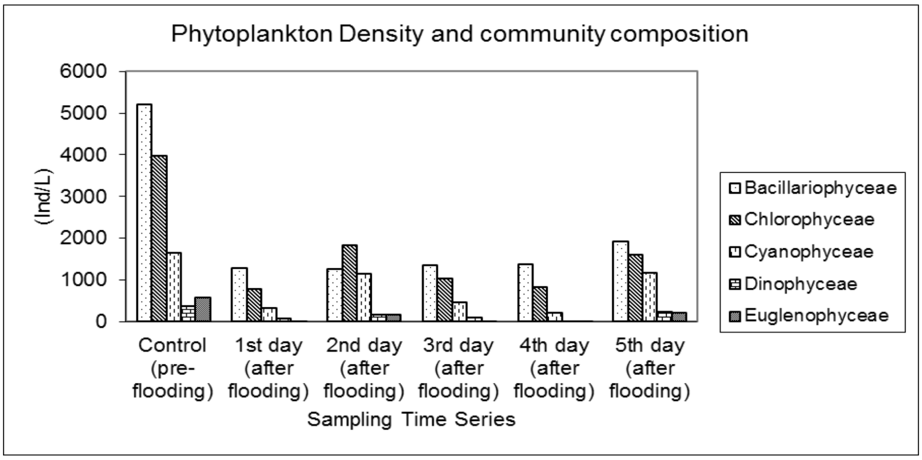

Fig. 2: Community composition of the phytoplankton and its density during pre and post flooding period.

The biomass of the major groups was comparatively small after the flash flood except for the group of Cyanophyceae. In such group, the biomass of all species was significantly smaller than biomass of the same species during the pre flooding period as shown in Table (2). After 5th day of flooding, a part from Bacillariophyceae (*Amphora* sp., *Navicula* sp. and *Surerella* sp.) and Chlorophyceae (*Pediastum* sp., *Chlorella* sp. and *Staurastrum* sp.), Dinophyceae (*Peridinium* sp. and *Ceratium* sp.) and Euglenophyceae (*Phacus* sp.) showed exceptional biomass values that statistically reached the same values during the pre flooding period. This result was influenced by the flash flood conditions predominate, with phytoplankton assemblages dominated by species tolerant to turbulent conditions and typical high turbidity. This coincides with the results of (Reynolds, *et al*., 2002 and Talling *et al*.,

2009) who mentioned that some species of phytoplankton can resist the high turbulent condition.

Concerning the density of zooplankton, the present result showed that there were (5) major groups of zooplankton found in the Damietta Branch as shown in Figure (3) and Table (3). These major groups were the Rotifera, Protozoa, Cladocera, Copepoda and Crustacea. Rotifera was the most diversified group (13 taxa), followed by protozoa (12 taxa), cladocera (10 taxa), Copepoda (5 taxa) and Crustacea (2 taxa). Statistical analyses results showed that the zooplankton biomass was generally more numerous during the pre flooding period and it declined during the flooding period and never regained its highest biomass even after more than 4 days post the flooding period. Although zooplankton abundance decreased dramatically in response to flood events as the result of dilution, changes in the taxonomic composition of zooplankton were occurred during 5 days of post flooding. In this case, rotifera species of (*Asplanchna* sp., *Polyrthra* sp., *Synchaeta* sp., *Euchanis* sp., *Platyas* sp. and *Ascomorpha* sp; the protozoan, *Centropxis* sp., *Carchesium* sp., *Diffligia* sp., *Acropisthium* sp. and *Cyphoderia* sp.); the cladoceran species of (*Ceriodaphnia* sp., *Daphnia* sp., *Moina* sp., *Monosplius* sp. and *Ilyocryptus* sp.); the copepoda species of (*Cyclops* sp. and *Nitocra* sp.) and the crustacean species of (*Cardina* sp. and *Chlamydothea* sp.) showed statistically greater proportional abundance similar to the pre flooding period. This result coincides with the increase in some phytoplankton during 5 days post flooding that can be explained as explain as zooplankton predator-phytoplankton prey cycle. This result is in good accordance with those given by (Schemel, *et al*. 2004; Sobczak, *et al.* 2005) who mentioned that the zooplankton biomass is depending on the phytoplankton availability. Other factor such as the impact of zooplankton nutrient regeneration can be rapidly assimilated into phytoplankton growth (Hunt and Matveev 2005).

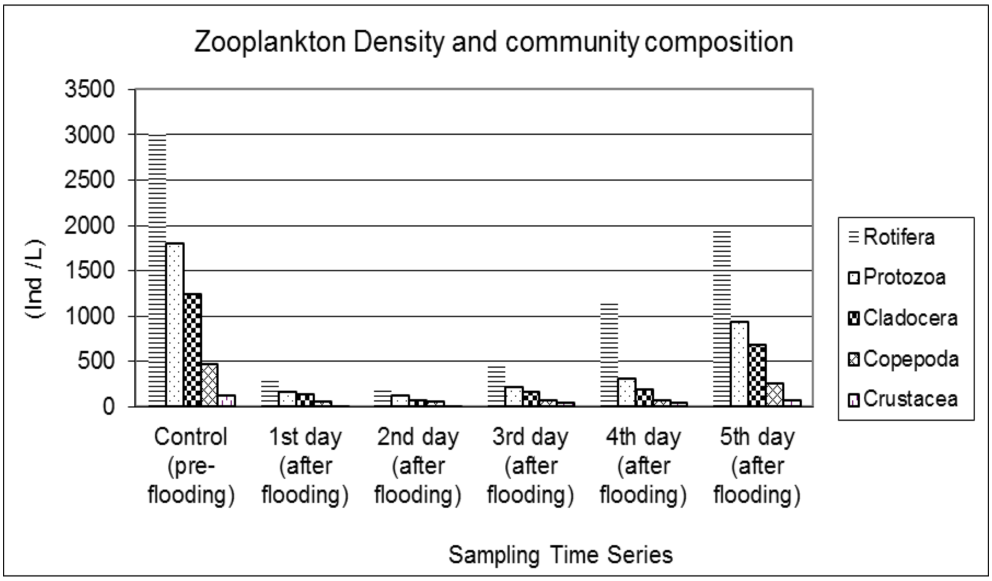

Fig. 3: Community composition of the zooplankton and its density during pre and post flooding period

Table 1: Concentrations of different parameters in the surface water during pre and after flooding period and their statistical values

Parameters	**Control (pre-flooding)**			**1st day (after flooding)**				**2nd day (after flooding)**				**3rd day (after flooding)**				**4th day (after flooding)**				**5th day (after flooding)**			
	Mean	**S.D.**	**df**	**Mean**	**S.D.**	**t**	**Sig.**	**Mean**	**S.D.**	**t**	**Sig.**	**Mean**	**S.D.**	**t**	**Sig.**	**Mean**	**S.D.**	**t**	**Sig.**	**Mean**	**S.D.**	**t**	**Sig.**
Temp (ºC)	23.34	0.36	9	23.65	0.27	1.93	0.09	23.58	0.34	1.8	0.09	23.08	0.04	2.14	0.06	22.58	0.10	7.58	**0.00**	22.72	0.24	3.37	**0.01**
pH	8.1	0.00	9	8.68	0.01	194.54	**0.00**	8.68	0.01	129.16	**0.00**	8.73	0.00	474	**0.00**	8.64	0.03	57.55	**0.00**	8.58	0.23	6.69	**0.00**
ORP (millivolts)	215.98	112.7	9	266.82	3.487	1.443	0.18	261.04	1.04	1.27	0.24	252.4	0.8	1.03	0.33	284.64	10.59	1.10	0.08	271.46	12.50	1.63	0.14
EC (µs/cm)	457.8	8.50	9	149.1	67.35	14.10	**0.00**	381.84	63.39	4.127	**0.00**	422.2	29.10	4.13	**0.00**	359.41	77	3.77	**0.00**	328.33	11.71	24.78	**٠.00**
CO (mg/l)	733.06	33.3٤	9	826.47	31.83	5.57	**0.00**	870.86	47.30	7.13	**0.00**	841.6	7.60	10.16	**0.00**	919.07	31.19	14.06	**0.00**	765.21	24.90	2.76	**0.02**
NO^3 (mg/l)	11.1	1.32	9	16.92	0.91	9.58	**0.00**	8.68	0.58	4.78	**0.00**	7.54	0.11	8.49	**0.00**	3.24	0.40	15.71	**0.00**	22.9	2.27	14.75	**0.00**
DO (mg/l)	6.21	0.70	9	6.818	0.54	5.40	**0.00**	6.883	1.88	9.88	**0.00**	6.764	0.41	2.418	**0.00**	6.239	0.55	0.83	0.43	6.209	0.70	1.814	**0.00**
TUR (NTU)	9.89	0.32	9	10.83	0.97	2.48	**0.04**	8.33	1.16	4.59	**0.00**	9.10	2.5	0.99	0.35	5.43	2.4	5.85	**0.00**	9.22	0.03	6.24	**0.00**

Bold Value (P) <0.05 = significance difference *Italic Value* (P) >0.05 = non- significance difference

Table 2: Frequencies of phytoplankton (genera and species) during pre and after flooding period and their statistical values

Parameters	**Control (pre- flooding)**			**1st day (after flooding)**				**2nd day (after flooding)**				**3rd day (after flooding)**				**4th day (after flooding)**				**5th day (after flooding)**			
	Mean	**S.D.**	**df**	**Mean**	**S.D.**	**t**	**Sig.**	**Mean**	**S.D.**	**t**	**Sig.**	**Mean**	**S.D.**	**t**	**Sig.**	**Mean**	**S.D.**	**t**	**Sig.**	**Mean**	**S.D.**	**t**	**Sig.**
Bacillariophyceae	5201.7	2618.2	9	1276.2	532.35	4.739	**0.001**	1243.8	458.39	5.610	**0.000**	1332.6	656.7	6.109	**0.000**	1371	557.91	5.543	**0.000**	1908	759.03	4.686	**0.000**
***Nitzschia* sp.**	603	308.29	9	195	147.59	3.921	**0.004**	123.9	54.09	5.679	**0.000**	146.7	133.4	5.503	**0.000**	178.2	193.57	3.273	**0.010**	246	144.47	3.271	**0.010**
***Synedra* sp.**	433.5	176.5	9	196.2	123.75	5.564	**0.000**	79.8	39.97	7.214	**0.000**	91.2	36.85	7.027	**0.000**	270	368.3	1.540	*0.158*	214.5	95.6	4.882	**0.001**
***Melosira* sp.**	351	241.69	9	152.7	85.85	2.241	*0.052*	103.2	89.1	3.487	**0.007**	76.2	85.8	3.725	**0.005**	223.5	340.47	1.740	*0.116*	90	58.9	3.723	**0.005**
***Cyclotella* sp.**	511.5	354.07	9	64.9	48.2	3.837	**0.004**	112.5	57.18	3.659	**0.005**	96.9	39.8	3.959	**0.003**	223.5	340.5	2.125	*0.063*	102	64.7	4.073	**0.003**
***Fragilaria* sp.**	429	340.56	9	73.4	59.7	3.331	**0.009**	97.8	42.4	3.279	**0.010**	195	249.4	2.428	**0.038**	63	46.76	3.273	**0.010**	126	85.5	2.478	**0.035**
***Amphora* sp.**	229.2	118.58	9	43.9	46.87	6.608	**0.000**	136.2	107.3	3.309	**0.009**	85.8	48.7	4.687	**0.001**	81.6	50.9	4.309	**0.002**	151.5	123.87	2.167	*0.058*
***Navicula* sp.**	424.5	300.02	9	114	54.5	3.121	**0.012**	77.1	68.8	4.578	**0.001**	82.8	61.7	3.316	**0.009**	72	51.5	3.738	**0.005**	258	152.5	1.424	*0.188*
***Diatoma* sp.**	342	201.7	9	43.1	43.2	4.289	**0.002**	80.4	64.15	4.581	**0.001**	78.9	45.79	4.906	**0.001**	54.9	52.76	4.001	**0.003**	139.5	87.7	2.941	**0.016**
***Asterionella* sp.**	499.5	420	9	39.9	64.3	3.203	**0.011**	96	54.6	3.178	**0.011**	102.9	64.77	3.362	**0.008**	39.6	56.2	3.513	**0.007**	112.5	58.5	3.181	**0.011**
***Gyrosigma* sp.**	430.5	321.2	9	38.1	35.16	4.156	**0.002**	100.2	53.77	3.530	**0.006**	84.9	42.99	3.533	**0.006**	77.1	40.44	3.520	**0.007**	141	90.79	3.232	**0.010**
***Eunotia* sp.**	250.5	119.7	9	104.1	39.19	5.141	**0.001**	67.2	54.6	4.981	**0.001**	98.4	48.69	5.432	**0.000**	84.3	72.57	4.206	**0.002**	61.5	50.61	4.414	**0.002**
***Bacillaria* sp.**	513	393.8	9	127.4	121.5	2.667	**0.026**	94.8	43.9	3.438	**0.007**	91.5	45.9	3.367	**0.008**	70.8	50.29	3.678	**0.005**	99	52.16	3.251	**0.010**
***Surirella* sp.**	184.5	71.27	9	78	60.5	3.494	**0.007**	74.7	40.39	7.488	**0.000**	101.4	55.8	5.258	**0.001**	68.4	46.87	4.909	**0.001**	166.5	106.3	.643	*0.536*
Chlorophyceae	3957	2037	9	764.7	338.75	5.602	**0.000**	1825.8	672.4	4.277	**0.002**	1025.4	386.19	5.009	**0.001**	825	338.86	5.267	**0.001**	1597.5	765.56	5.397	**0.000**
***Dictyocphaerium* sp.**	396	274.18	9	48	61.2	3.955	**0.003**	81	47.9	3.869	**0.004**	57.6	55.7	4.688	**0.001**	55.5	48.6	3.715	**0.005**	157.5	117.05	2.589	**0.029**
***Oocystis* sp.**	220.5	135.7	9	35.7	31.9	5.263	**0.001**	87.6	49.23	2.921	**0.017**	35.1	40.7	4.572	**0.001**	24.9	41.9	4.461	**0.002**	75	95.59	2.812	**0.020**
***Pediastrum* sp.**	195	108.26	9	40.5	48.55	5.719	**0.000**	123.9	73.39	4.405	**0.002**	64.2	49.25	3.077	**0.013**	39	39.12	5.296	**0.000**	169.5	170.88	0.420	*0.684*
***Actinastrumn* sp.**	138	58.27	9	64.5	57.5	2.749	**0.023**	81	57.79	2.255	**0.051**	57	38.12	5.687	**0.000**	72.3	60.46	3.744	**0.005**	61.5	28.96	4.471	**0.002**
***Coelastrum* sp.**	141	64.9	9	37.5	33	6.546	**0.000**	99.6	47.89	4.245	**0.002**	76.5	50.1	2.730	**0.023**	51.6	48.5	3.839	**0.004**	87	72.88	2.361	**0.043**
***Scenedsums* sp.**	231	175	9	70.5	45.8	2.866	**0.019**	78.6	58.39	2.740	**0.023**	65.7	29.9	2.973	**0.016**	22.2	11.7	3.785	**0.004**	67.5	60.6	2.788	**0.021**
***Volvox* sp.**	535.5	418.7	9	85.5	79.2	3.496	**0.007**	233.4	192	1.852	*0.097*	44.1	41.88	3.595	**0.006**	96	51.7	3.610	**0.006**	136.5	126.4	3.673	**0.005**
***Chlorella* sp.**	264	284.8	9	36	27.47	2.581	**0.030**	111	64.4	2.131	*0.062*	84.6	58.05	2.133	0.062	47.1	45.6	2.554	**0.031**	162	137.96	2.015	*0.075*
***Staurastrum* sp.**	139.5	121	9	39	46.29	2.352	**0.043**	90.6	54.9	1.429	*0.187*	60.6	36.58	2.065	0.069	70.5	64.5	1.543	*0.157*	93	71.5	0.990	*0.348*
***Selenastrum* sp.**	238.5	258	9	39	39.49	2.522	**0.033**	113.1	59.3	1.643	*0.135*	30.6	22.7	2.533	**0.032**	15.3	19	2.668	**0.026**	48	11.6	2.338	**0.044**
***Spirogyra* sp.**	130.5	75.6	9	78	40	2.327	**0.045**	99.6	42.6	1.393	*0.197*	51.9	45.15	4.317	**0.002**	85.5	49.3	4.223	**0.002**	87	71.5	4.780	**0.001**
***Eudorina* sp.**	256.5	200.8	9	28.5	38	3.335	**0.009**	95.4	74.1	2.366	**0.042**	70.5	42.96	2.975	**0.016**	22.8	25.67	4.188	**0.002**	117	63.77	2.454	**0.037**
***Closterium* sp.**	264	138.66	9	61.5	71.7	3.877	**0.004**	96.6	59.36	3.509	**0.007**	85.5	51.34	5.284	**0.001**	83.7	68.5	3.844	**0.004**	129	130.4	4.507	**0.001**
***Sphaerocystis* sp.**	133.5	105.75	9	36	26.4	2.811	**0.020**	112.8	58	0.488	*0.637*	36.9	34.8	3.021	**0.014**	26.4	23.78	2.968	**0.016**	58.5	46.7	1.880	*0.093*
***Tetrachlorella* sp.**	204	154.86	9	18	20.4	3.975	**0.003**	101.4	68.89	1.712	*0.121*	72.9	53.59	3.263	**0.010**	42.9	57.56	3.800	**0.004**	49.5	43.93	2.767	**0.022**
***Radiococcus* sp.**	214.5	104.6	9	25.5	34.75	5.741	**0.000**	125.7	46.57	4.116	**0.003**	69.9	43.97	5.039	**0.001**	33.3	46.8	7.383	**0.000**	43.5	39	4.998	**0.001**
***Asteriococcus* sp.**	255	297.86	9	21	21.3	2.516	**0.033**	94.5	55.8	1.925	*0.086*	61.8	29.88	1.986	*0.078*	36	46.88	2.175	*0.058*	55.5	44.18	2.376	**0.041**
Cyanophyceae	1642.5	837.6	9	307.5	205.97	6.426	**0.000**	1140	550.2	4.191	**0.002**	457.2	180.63	4.827	**0.001**	201.9	83.2	5.584	**0.000**	1156.5	458.31	2.165	*0.059*
***Microcystis* sp.**	204	115.87	9	42	55.8	3.912	**0.004**	156	95.3٩	0.946	*0.369*	17.7	13.05	5.615	**0.000**	19.8	16.2	5.053	**0.001**	147	128.4	0.887	*0.398*
***Gomphosphaeria* sp.**	189	170.8	9	70.5	64.05	2.779	**0.021**	148.5	219.5	0.866	*0.409*	65.1	36.81	2.418	**0.039**	33	40.36	3.299	**0.009**	105	108.01	2.224	*0.053*
***Oscillatoria* sp.**	192	126.6	9	21	16.12	4.362	**0.002**	168	162.36	0.324	*0.753*	24.9	16.55	4.276	**0.002**	4.8	10.8	4.862	**0.001**	180	101.5	0.462	*0.655*
***Chroococcus* sp.**	267.99	326.99	9	22.5	32.6	2.287	**0.048**	126	59.15	1.476	*0.174*	34.8	31.69	2.131	*0.062*	15.9	21.5	2.390	**0.041**	124.5	77.7	1.565	*0.152*
***Lyngbya* sp.**	124.5	97.39	9	19.5	19.9	3.245	**0.010**	120	68.7	0.130	*0.899*	55.8	61.28	2.321	**0.045**	25.2	34.6	3.774	**0.004**	117	79.48	0.212	*0.837*

***Anabaena* sp.**	174	125.16	9	22.5	12.08	4.205	**0.002**	138	65.24	0.928	*0.378*	39.6	43.03	3.735	**0.005**	26.1	17.99	3.778	**0.004**	120	71.88	1.253	*0.242*
***Merismopedia* sp.**	105	48.8٨	9	31.5	31.09	5.628	**0.000**	99	42.48	0.435	*0.674*	60.3	57.16	2.582	**0.030**	17.4	8.04	6.175	**0.000**	96	66.32	0.335	*0.745*
***Coelosphaerium* sp.**	108	71.1٩	9	34.5	44.37	4.295	**0.002**	91.5	56.67	0.612	*0.556*	75.3	51.5	2.510	**0.033**	28.2	18.07	4.356	**0.002**	91.5	70.83	0.625	*0.547*
***Spirulina* sp.**	151.5	142.44	9	24	21.7	2.843	**0.019**	27	12.7	2.942	**0.016**	50.7	38.8	2.044	*0.071*	14.7	7.8	3.060	**0.014**	61.5	61.96	1.704	*0.123*
***Phormidium* sp.**	127.5	52.77	9	19.5	15.17	6.814	**0.000**	66	42.41	3.324	**0.009**	33	29	6.337	**0.000**	16.8	12.76	6.517	**0.000**	114	68.5	0.687	*0.510*
Dinophyceae	355.5	181.5	9	70.5	55.45	5.027	**0.001**	151.5	90.12	3.352	**0.008**	86.1	48.9	5.655	**0.000**	32.1	16.6	5.763	**0.000**	219	78.6	3.101	**0.013**
***Peridinium* sp.**	171	119.18	9	22.5	12.07	4.019	**0.003**	94.5	65.88	1.764	*0.112*	44.1	36.7	3.079	**0.013**	19.8	9.24	4.057	**0.003**	116	51.3	1.684	*0.126*
***Ceratium* sp.**	184.5	167.57	9	48	54.73	2.143	*0.061*	57	49.7	2.372	**0.042**	42	27.9	2.598	**0.029**	12.3	10.3	3.189	**0.011**	103	55.3	1.419	*0.190*
Euglenophyceae	565.5	352.17	9	43.5	33.25	4.894	**0.001**	144	111.5	4.538	**0.001**	27.6	15.22	4.915	**0.001**	23.7	12.86	4.924	**0.001**	192.3	96.38	3.779	**0.004**
***Euglena* sp.**	220.5	149.7	9	27	23.47	4.006	**0.003**	19.5	14.37	4.221	**0.002**	16.8	6.12	4.409	**0.002**	9.9	8.72	4.370	**0.002**	79.5	81.25	2.589	**0.029**
***Phacus* sp.**	220.5	149.78	9	16.5	15.46	4.448	**0.002**	8.9	9.25	4.386	**0.002**	10.8	12.88	4.473	**0.002**	16.3	11.15	4.276	**0.002**	112.8	69.59	1.958	*0.082*

Bold Value (P) <0.05 = significance difference

Italic Value (P) >0.05 = non- significance difference

Table (3) Frequencies of zooplankton (genera and species) during pre and after flooding period and their statistical value

Parameters	**Control (pre- flooding)**			**1st day (after flooding)**				**2nd day (after flooding)**				**3rd day (after flooding)**				**4th day (after flooding)**				**5th day (after flooding)**			
	Mean	**S.D.**	**df**	**Mean**	**S.D.**	**t**	**Sig.**	**Mean**	**S.D.**	**t**	**Sig.**	**Mean**	**S.D.**	**t**	**Sig.**	**Mean**	**S.D.**	**t**	**Sig.**	**Mean**	**S.D.**	**t**	**Sig.**
Rotifera	3026.2	1139.6	9	269.4	100.54	8.262	**0.000**	175.9	70.54	8.241	**0.000**	466.2	176.22	8.007	**0.000**	1122.9	418.37	7.446	**0.000**	1928.4	787.06	5.865	**0.000**
Brachionus sp.	435	290.45	9	39.9	21.38	4.384	**0.002**	17.1	12.69	4.642	**0.001**	28.8	13.1	4.473	**0.002**	125.4	64.39	3.784	**0.004**	139.5	67.8	3.854	**0.004**
Keratella sp.	219	150.42	9	34.8	16.05	3.902	**0.004**	8.7	12.68	4.335	**0.002**	15.6	14.36	4.116	**0.003**	69	68.21	2.870	**0.018**	68.7	40.11	3.143	**0.012**
Asplanchna sp.	312	221.06	9	6.6	10.66	4.347	**0.002**	10.5	10.55	4.355	**0.002**	57.9	54.27	3.427	**0.008**	101.1	71.92	3.767	**0.004**	156.9	226.1	1.735	*0.117*
Trichocerca sp.	298.5	167.69	9	18.9	7.17	5.385	**0.000**	17.1	17.25	5.646	**0.000**	74.4	62.32	4.484	**0.002**	134.7	73.35	3.165	**0.011**	177.6	129.8	2.455	**0.036**
Polyarthra sp.	279	323.32	9	24.3	17.7	2.536	**0.032**	12.3	5.79	2.626	**0.028**	22.2	25.3	2.438	**0.038**	64.8	56.8	2.159	*0.059*	264	325.08	0.095	*0.927*
Pompholyx sp.	176.7	125.9	9	19.5	27.51	3.804	**0.004**	13.8	9.69	4.404	**0.002**	51.9	52.04	4.900	**0.001**	107.7	80.14	1.205	*0.259*	246.3	166.1	2.725	**0.023**
Synchaeta sp.	274.5	185.17	9	18.3	19.7	4.297	**0.002**	10.2	11.3	4.550	**0.001**	21.9	12.6	4.335	**0.002**	66.9	42.26	3.332	**0.009**	289.2	301.2	0.163	*0.874*
Euchanis sp.	192	127.95	9	20.4	16.15	4.532	**0.001**	22.5	10.44	4.537	**0.001**	31.5	26.98	3.933	**0.003**	149.1	149.47	1.866	0.095	109.2	49.65	1.925	*0.086*
Platyas sp.	139.5	98.89	9	17.1	11.45	3.711	**0.005**	8.4	8.59	4.211	**0.002**	21.6	17.9	3.589	**0.006**	69.9	41.02	2.730	**0.023**	72.6	36.18	2.001	*0.076*
Ascomorpha sp.	130.5	92.23	9	6.9	9.82	4.290	**0.002**	12.3	17.92	3.770	**0.004**	29.7	22.12	3.433	**0.007**	73.2	78.26	1.648	*0.134*	98.7	55.79	1.21	*0.257*
Testudinella sp.	181.5	92.9	9	24	26.58	5.565	**0.000**	7.2	7.31	6.057	**0.000**	41.1	44.52	3.936	**0.003**	33.6	25.05	5.881	**0.000**	87.6	35.53	3.634	**0.005**
Filina sp.	213	143	9	23.1	11.54	4.355	**0.002**	11.7	9.52	4.360	**0.002**	32.7	41.87	4.618	**0.001**	61.8	77.67	3.602	**0.006**	105.6	72.1	2.772	**0.022**
Lecane sp.	169.5	97.93	9	15.6	16.78	4.905	**0.001**	18.6	20.11	4.779	**0.001**	36.9	28.36	4.495	**0.001**	65.7	62.68	5.899	**0.000**	112.5	72.29	2.288	**0.048**
Protozoa	1792.8	830.7	9	153.6	58.47	6.618	**0.000**	109.5	45.9	6.653	**0.000**	212.1	79.68	6.351	**0.000**	297.9	118.7	6.082	**0.000**	930.6	362.7	5.157	**0.001**
Epistylis sp.	222	145.29	9	23.1	18.28	4.822	**0.001**	6.6	4.5	4.760	**0.001**	30.9	24.39	4.377	**0.002**	30	49.43	4.502	**0.001**	63.9	54.13	3.423	**.008**

Lacrymaria sp.	240.9	194.8	9	17.4	6.6	3.665	**0.005**	7.5	8.3	3.858	**0.004**	17.1	14.45	3.830	**0.004**	24.9	18.36	3.632	**0.005**	72.3	45.3	2.970	**0.016**
Centropyxis sp.	119.4	63.28	9	8.4	14.5	5.971	**0.000**	12.3	5.49	5.476	**0.000**	22.5	16.16	6.083	**0.000**	24.3	10.59	5.106	**0.001**	78.9	45.97	1.718	*0.120*
Arcella sp.	205.8	175.87	9	9	11.45	3.488	**0.007**	4.8	3.79	3.595	**0.006**	9.9	15.07	3.677	**0.005**	30	49.74	2.920	**0.017**	76.5	63.92	2.404	**0.040**
Vorticella sp.	141.3	64.77	9	15.9	13.56	7.148	**0.000**	15.9	12.36	6.840	**0.000**	13.8	6.95	6.327	**0.000**	35.1	57.14	3.592	**0.006**	83.1	53.59	2.905	**0.017**
Euplotes sp.	117.3	58.81	9	10.5	10.55	5.670	**0.000**	10.2	9.3	5.458	**0.000**	12.9	9	5.951	**0.000**	16.5	11.89	5.296	**0.000**	73.8	40.5	2.876	**0.018**
Paradileptus sp.	103.8	64.2	9	13.5	8.95	4.733	**0.001**	9.3	7.45	5.020	**0.001**	21.3	15.73	4.653	**0.001**	30	13.82	3.937	**0.003**	54.3	40.26	2.698	**0.024**
Carchesium sp.	87.3	44.81	9	14.1	7.5	5.559	**0.000**	5.7	8.02	5.445	**0.000**	17.1	13.54	4.537	**0.001**	44.7	43.68	4.584	**0.001**	107.7	54.71	0.996	*0.345*
Difflugia sp.	117.6	73.13	9	5.4	7.58	4.640	**0.001**	5.7	5.77	4.733	**0.001**	27.6	16.6	3.685	**0.005**	15.3	13.39	4.150	**0.002**	92.4	47.6	2.220	*0.054*
Acropisthium sp.	108.6	85.68	9	11.1	11.12	3.803	**0.004**	11.1	7.32	3.840	**0.004**	20.1	12.08	3.338	**0.009**	8.4	11.85	3.626	**0.006**	62.4	37.61	1.742	*0.116*
Tokophrya sp.	162.3	62.74	9	13.8	12.13	8.116	**0.000**	7.5	5.7	7.935	**0.000**	7.5	7.32	8.159	**0.000**	21.3	10.2	7.690	**0.000**	62.7	47.29	5.050	**0.001**
Cyphoderia sp.	166.5	198.8	9	11.4	6.05	2.435	**0.038**	12.9	4.8	2.451	**0.037**	11.4	8.5	2.528	**0.032**	17.4	9.84	2.346	**0.044**	102.6	48.49	1.114	*0.294*
Cladocera	1238.1	773.18	9	126.9	46.7	4.622	**0.001**	127.2	59.1	4.578	**0.001**	159	58.56	4.615	**0.001**	185.7	72.3	4.461	**0.002**	672	266.93	2.460	**0.036**
Alona sp.	101.1	68.9	9	9	11.45	4.576	**0.001**	12.6	9.55	4.511	**0.001**	11.7	7.86	4.064	**0.003**	20.1	11.22	3.821	**0.004**	48.9	42	3.204	**0.011**
Bosmina sp.	243.3	280.62	9	18	8.49	2.594	**0.029**	9.6	9.47	2.603	**0.029**	16.5	9.8	2.532	**0.032**	33.9	28.56	2.345	**0.044**	36.9	16.4	2.347	**0.044**
Ceriodaphnia sp.	150	150.39	9	15.3	10.97	2.926	**0.017**	9.3	13.58	2.828	**0.020**	12.6	8.83	2.997	**0.015**	12.3	12.2	2.798	**0.021**	63.6	34.89	1.679	*0.127*
Daphnia sp.	98.7	48.57	9	18.9	13	4.988	**0.001**	11.7	8.34	5.474	**0.000**	17.4	17.95	6.012	**0.000**	18.9	14.69	6.234	**0.000**	103.2	107.93	0.121	*0.906*
Chydorus sp.	122.7	50.69	9	13.8	13.48	6.973	**0.000**	12.6	8.57	7.437	**0.000**	19.5	9.7	6.855	**0.000**	13.5	16.02	6.716	**0.000**	72.9	35.65	3.001	**0.015**
Moina sp.	157.5	196.75	9	6.9	6.9	2.470	**0.036**	24.9	34.16	2.098	*0.065*	16.5	18.6	2.182	**0.057**	16.8	7.2	2.305	**0.047**	64.2	53.13	1.342	*0.213*
Diaphanosoma sp.	54.3	42.49	9	12.6	8.95	3.260	**0.010**	11.4	14.6	3.754	**0.005**	17.4	13.95	3.404	**0.008**	13.8	14.85	2.739	**0.023**	86.1	35.9	- 2.847	**0.019**

Macrothrix sp.	124.2	47.15	9	7.5	7.97	8.643	**0.000**	7.8	7.68	8.150	**0.000**	17.1	12.52	8.658	**0.000**	18.9	10.96	7.585	**0.000**	30	15.77	8.120	**0.000**
Monospilus sp.	89.1	35.9	9	9.9	10.35	6.939	**0.000**	12.9	10.22	6.829	**0.000**	11.7	9.6	8.093	**0.000**	20.1	14.35	6.238	**0.000**	97.2	49.63	0.583	*0.574*
Ilyocryptus sp.	97.2	74.36	9	15	12.99	3.571	**0.006**	14.4	6.022	3.545	**0.006**	18.6	13.08	3.324	**0.009**	17.4	15.88	3.298	**0.009**	69	43.99	1.050	*0.321*
Copepoda	456.3	182.57	9	53.7	21.5	7.616	**0.000**	51.6	20	7.652	**0.000**	63.6	23.85	7.468	**0.000**	64.2	25.2	7.638	**0.000**	251.4	116.05	7.307	**0.000**
Mesocyclops sp.	114	64.48	9	15.9	13.15	5.598	**0.000**	14.4	7.5	5.232	**0.001**	12.9	6.67	5.320	**0.000**	18.9	14.03	4.598	**0.001**	60.6	49.6	2.363	**0.042**
Diaptomus sp.	77.1	31.35	9	9.3	7.37	6.935	**0.000**	8.7	8.61	6.846	**0.000**	13.2	10.58	6.689	**0.000**	12.9	13.54	5.729	**0.000**	36	30.34	2.887	**0.018**
Cyclops sp.	96.9	75.65	9	9.6	7.5	3.522	**0.006**	9.3	7.2	3.537	**0.006**	15.9	9.46	3.282	**0.009**	14.1	12.5	3.275	**0.010**	39.3	39.5	1.907	*0.089*
Halicyclops sp.	76.2	38.3	9	12	6.2	6.161	**0.000**	11.4	11.4	5.896	**0.000**	10.5	7.39	6.439	**0.000**	6.3	6.39	5.480	**0.000**	41.7	32.48	4.773	**0.001**
Nitocra sp.	92.1	48.39	9	6.9	7.14	6.279	**0.000**	7.8	6.16	5.403	**0.000**	11.1	7.83	5.797	**0.000**	12	8.02	5.831	**0.000**	73.8	59.15	1.898	*0.090*
Crustacea	111.9	45.7	9	20.7	11.59	6.637	**0.000**	23.1	11.34	7.178	**0.000**	29.1	10.7	7.045	**0.000**	29.1	10.7	7.045	**0.000**	64.2	42.03	3.173	**0.011**
Cardina sp.	61.8	43.25	9	11.4	7.96	3.976	**0.003**	12.6	8.64	3.531	**0.006**	11.7	8.47	3.636	**0.005**	11.4	7.89	3.439	**0.007**	32.1	31.32	1.690	*0.125*
Chlamydotheca sp.	50.1	36.82	9	9.3	5.57	3.570	**0.006**	10.5	7.47	3.919	**0.004**	17.4	11.79	2.552	**0.031**	17.4	11.79	2.552	**0.031**	32.1	32.66	2.300	*0.05*

Bold Value (P) <0.05 = significance difference

Italic Value (P) >0.05 = non- significance difference

CONCLUSION

In this study, statistical techniques by using different physio-chemical and biological parameters were successfully applied to evaluate the temporal variations in Damietta Branch water quality due to the extreme floods that hit Upper Egypt on October 2016. It is clear that the flood was the meaningfully enforce water quality changes and reduction of phytoplankton and zooplankton populations.

Comprehensive studies and simulating the water body; using hydrological models along the Damietta Branch are required to assess the impact of extreme events on the anthropogenic activities.

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